CONSIDERATIONS ON THE HEALTH OF THE SPONGE DIVERS

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The recent application of underwater apparatus for fishing for sponges, offers from the point of view of the commercial benefits, such advantages over the old mode utilised for this fishing, that one is able, already to foresee times when the divers will only descend to the depths of the sea while wearing one of these apparatuses.

But besides the advantages which result from this progress, some serious accidents, of a particular nature, have attracted the attention of the health workers. His duty is to research their causes, to explain their nature and to identify, if possible, the way of preventing them. Already some remarkable studies of incontestable practicality have been published on work in compressed air: up to now it raised the question how to preserve the health of the men subjected to the pressure of three atmospheres at the most; today, the sponge divers descend to depths under the sea of 45 to 55 metres, that is to say that they support (taking into account one normal atmosphere) 5 to 6 atmospheres.

It is indispensable for the development of our subject to include some of the details of sponge fishing as it has been practised for centuries and of its importance in relation to the introduction of underwater apparatus; With this aim, we can profit from the information contained in a hand written memoire redacted by M Aublé, agent for the *Society for sponge diving by means of the diving apparatus of Rouquayrol and Denayrouze*.

Whilst sponges can be found and collected from the bottom of different seas around the world, such as the Red Sea, the sea of the Antilles, it is the basin of the Mediterranean that is its main centre of production. If leaving the gulf of Syrte, from the east coast of Tunisia one goes following the African coast towards Alexandria, and then, from there going up the coast of Syria until as far as that of Asia Minor, if one also travels the coast of the Greek archipelago, the islands of Candie and Cyprus, one will have defined the huge perimeter where the industry of sponge diving is carried out.

The depths to which one recovers this marine product vary greatly. They vary from 25 to 65 metres. It is on the African coast and along that of Caramanie that one descends the most deeply, it is where the most skilful divers congregate. In general, the greater the depths that sponges are recovered, the more abundant, fine and well-formed they are.

In the Ottoman archipelago, it is especially on the islands of Kalkic, Simi and Calymnos, that are found concentrations of the men who indulge in this dangerous form of fishing. In the last years, one is able to estimate their number at about 4,000. The boats are normally about 6 to 7 tonneaux*, (17 to 20 m3); they are manned by 7 to 8 men of whom only four are divers, the others navigate. The crews of these boats are completely at the

mercy of the owners or sleeping partners who are to the fishermen of the archipelago what the “ecoreurs” are to the fishermen in the north of France.

Towards the end of the month of March, the crews are established, and preparation of the boats is in place by April. In the middle of May all the fishing boats are at sea. They don't return until the beginning of October. The revenus of this industry despite the shortcomings of the means employed is considerable, since, in only those few months between 1863 to 1866 the average value of the catch was each year of 3 million.

With the exception a few boats manned by old diversby then incapable of diving and who fish either with the aid of a harpoon or of a drag-net, on all the boats fishermen practice “free” or “breath hold” diving.

The diver of the archipelago is well built, strong, he has a large chest, an alert bearing. He is proud of his condition; as long as he is young, he is able to reach great depths, to be master diver, *sarronda aries* (who descend to 40 fathoms) as they say in their language.

But in this profession, he loses his sense of hearing early, ages quickly, and death is common amongst these men because of the dangers that they face and of the perturbations that the time spent underwater must inflict on their higher functions.

After having thrown oil or “sponge milk” on the surface of the water in order to better see the depth and after having taken deep breaths to expand his lungs as much as possible, the diver dives head-first holding between his hands a stone tied to a rope to give signals; this stone rapidly takes him to the bottom. Another rope attached one end to the signal rope and the other to his body allows the diver to return to the signal rope which he has momentarily abandoned and which remains fixed to the bottom by the stone deposited there. He then gathers within the range of the rope which he drags after him, with a lightness, speed and a remarkable skill, the sponges which he can reach. He puts them into a bag which hangs in front of his chest; when he wants to go up he makes the appropriate signal and he is pulled up very rapidly back to the air.

The most skilled divers manage to stay on the bottom for 2, 3 and even, some say, 4 minutes. This last figure, we hasten to say, seems to us exaggerated.

A single diver is able, during his day, to go to the bottom some 5 to 10 times.

When the depth attained has been considerable, the rapid decompression results, when the fisherman reaches the air, in the loss of a variable quantity of blood from the ears, nose and mouth.

Thanks to the habit acquired by a practice that begins from a young age, serious accidents do not happen immediately other than those which we have just indicated and dullness of hearing. During his stay underwater the diver is exposed to two great dangers: he could become the prey of a shark or more likely, if tempted too far from his signal cord by the lure of his booty he frees himself from the cord attached to his body, and can no longer

find it: incapable on his own of return to the surface, he succumbs to asphyxia by submersion.

The diving equipment that we are concerned with today are superior than the ancient methods, they offer the advantage of overcoming these dangers. One alleges there would not be have been any example of a shark having attacked a man dressed as a diver.

It has been no more than 10 years since for the first time a trader from Paris dreamed of using the diving dress for this fishing. He took with him a diver from Toulon, who would teach the men of the archipelago how to use this equipment. One day the French diver being in the depths of the sea, was taken with grave symptoms which were never truly identified; there was time after an urgent signal to bring him back to the surface but he survived only a few hours. This unfortunate attempt discouraged the trader so much that he did not pursue his project.

In 1860 a local diver from the island of Simi came back from the Indies with diving equipment; he had worked with great success in this region in the pay of an English company. In recompense for his good services he had been given the equipment as a present when he left. He used it in the Mediterranean for sponge diving and he took excellent advantage of it.

In 1865 a diving dress belonging to a French company established in Constantinople and used by the people of Calymnos was destroyed by the people of this island. In their blindness the fishermen incited by their ship owners were convinced the apparatus would lead one day to the ruin of their industry.

Nevertheless the leap was taken; in 1866 seven sets were being used between Rhodes Simi and Calymnos. At the end of the campaign serious trouble broke out there were brawls and several apparatuses were destroyed. The head of the French Naval station of Levant intervened and together with the Turkish authorities the damage caused to our nationals was repaired and the freedom to fish with the aid of the diving equipment was proclaimed. The benefits obtained quickly convinced the fishermen of the superiority of the new method. One diving machine yields at least three times the catch of the best equipped ordinary fishing boat.

The important modifications introduced by Naval Lieutenant Denayrouze to the compressed air apparatus of the engineer Mr. Rouquayrol in order to make it applicable to underwater work led naturally to the use of this system for sponge diving. It was used during the campaign of 1867 with such success that at the beginning of this year a Society was formed for exploiting this industry on a large scale. Propeller vessels equipped with a 6-horse-power engine replaced the former sailing boats. Once at their fishing site the machine working comfortably operated round 4-6 pumps which supplied 4 divers underwater at the same time.

As part of the communication which we made to the Academy of Medicine (Meeting of 10 January 1865) on the cleaning of the holds of contaminated ships, we had the occasion

to describe this apparatus used by the Imperial Navy and that everyone was able to see working at the International Exhibition. We were able to restate the advantages over the former diving equipment. We can not today mention all the details again, that would take too long. Let us only say that during the campaign of 1867 there was not a single serious accident amongst the men who fished using the Rouquayrol Denayrouze equipment. But during the same time, out of 24 men who were using 12 diving equipment of English manufacture, 10 succumbed.

These accidents merit our complete attention. They raise a question of physiology and a question of professional health. Sponge diving, coral diving and of course the manufacture of compressed air equipment will henceforth occupy each year a larger number of men. One can see therefore that there are many good reasons for researching the source of these accidents and the means to prevent them if that is possible. It is the result of our thoughts on this subject that we have had the honour of presenting to the Academy; we do not pretend to have found the solution to the difficulties this problem raises; we have only formulated propositions over which we call the attention of physiologists and hygienists.

The absence of doctors in the fishing grounds and the difficulty of obtaining evidence from the fishermen of the archipelago who are by nature very suspicious, have not allowed us to arrive at a conclusion as we would have liked, on the nature of the phenomena which preceded the deaths of the 10 men we mentioned above. One has only been able to find out that three of them had died suddenly on leaving their underwater work and that the others had languished between 1 to 3 months paralysed in their lower limbs and bladder. Because of the presence of paraplegia in these 7 divers who survived for some time, it is reasonable to suppose up to a point that this phenomenon had existed equally in the 3 that succumbed rapidly.

What were the lesions which led to death of the unfortunate fishermen during the campaign of 1867 and how can one explain the mechanism which produced them? The absence of medical observations and especially of autopsies do not allow us to express an opinion on this subject except with great reserve. Paraplegia is, it is true, a phenomenon so characteristic and obvious that there is no need to be a doctor to report it. In one of the victims, a young and very hardy Greek diver such an extension of the bladder occurred that his father in the hope of relieving the unfortunate tried to puncture it; this caused a number of disorders that led to peritonitis rapidly fatal. We believe therefore that it is possible to conclude that in these cases a lesion of the spine had taken place and that this lesion has been a haemorrhage. Depending on the location and the intensity of this haemorrhage death happened very promptly as has been the case for three subjects, or has only happened after a variable time like for the 7 others.

What can be the cause of the spinal haemorrhage in these men who worked at great underwater depths supplied by compressed air apparatus. After deep reflection we have come to believe that it is the result of exaggerated tension of free gases in solution in the blood, as a result of the considerable pressure at which the divers are exposing themselves. Here are the reasons that have led us to this opinion.

The fishermen who “breath hold” dive never suffer similar accidents, even though they attain depths equal to those of the fishermen equipped with the diving apparatus, and who did succumb. The man who “free “ or “breath hold” dives, after having taken deep breaths carries in his chest only air at normal pressure and in quantity equal to the capacity of the extended pulmonary cells in which it is stored.

As he descends all of his body is subjected to greater and greater pressure which tends to flatten out the compressible cavities susceptible to reduce volume such as the abdomen and thorax. The gases that they contain are subjected to this pressure but during the few minutes that the diver stays under water, he does not renew his air supply; so the extra pressure that he is subjected to can only add a very tiny quantity to the total free gases dissolved in his blood at the cost of the air that is trapped in his pulmonary cells.

As man does not have, like cetacean, an arterial diverticulum which allows him to prolong his stay underwater, without renewing the air which is indispensable to the maintenance of life, he soon feels the imperious need to resurface. The sponge diver, naturally only make the signal to return at the last possible moment, and so he is recovered to the air very rapidly.

This brutal decompression to which he is subjected causes, we have said, small tears in the capillaries of the mucous material in the air passages; these tears are themselves the result of the tension of the free gases of which the blood is saturated. But in these cases, at the cost of these haemorrhages without consequence, the balance is soon re-established and the same diver is able to perform the same manoeuvre again several times in the same day.

The immunity is due in these conditions to the absence of respiration and to the short duration of the stay underwater.

Lets now see what happens to the man who descends, equipped with diving apparatus, to the same depths of the fisherman who “breath hold” dive . Inside the dive suit, as one knows, the man is completely isolated from the water with the aid of the dress made of strong, impermeable canvas, and of a metal helmet fixed onto the corselet of the dress. Air is sent to him in this envelope with the aid of a pump connected to it by means of a flexible hose attached to the back of the helmet. Nothing regulates, either the flow or the pressure of the air injected into this envelope. As result the worker often receives either too much or too little air; he is obliged in order to partly resolve the breathing discomfort that he suffers, to be constantly in touch with the pumpers by pulling signals given by means of a “signal line”. Nevertheless, thanks to the atmosphere that the man conserves around him, he is able to maintain his respiration and to stay whole hours at the bottom of the sea. But the greater the depth, the greater the duration is prolonged, the more the blood becomes charged with an excess of free gases in solution. The absence of a pressure regulator is likely to often cause the atmosphere of the envelope to be at a pressure greater than necessary. The man in reality, from a physical point of view, is in

the situation of a bottle of water which is charged with carbonic acid, in order to obtain artificial seltzer water.

When he resurfaces, if the decompression is insufficiently regulated, the gases which over saturate the blood, tend to come out with effervescence. Now, the experimenters who made injections into to the venous system of horses for example know that if one allows on purpose a small bubble of air in the liquid injected, the moment this bubble of air penetrates the circulation of the brain, the animal in the experiment remains as if struck dumb. This “struck dumb” condition, in this case is only momentary, but if the quantity of bubbles of air introduced is considerable, death follows rapidly.

Such is, we believe, the phenomenon which led to the death of the 10 divers from the archipelago during the campaign of 1867. It would remain to explain why the capillary haemorrhage has presented itself in the spinal cord rather than in the cerebral mass.

The cranial box and the spinal column form two envelopes equally incompressible, consequently, the blood driven back from the surface of the entire body and the compressible cavities must tend to congest in the cerebrospinal axis. The circulatory system of the medulla, compared to that of the brain is infinitely richer as demonstrated by the injections; finally, in the sponge diver it is his legs that get tired the most, on account that during his stay underwater he has to constantly walk, to climb, and to go down the rock slopes. Such perhaps are the causes which explain the frequency of accident around the medulla. We offer this explanation of course with the greatest reserve.

What seems to confirm the theory that we have offered is the complete immunity enjoyed, during the same campaign, by the men who worked equipped with the compressed air apparatus of Messrs Rouquayrol & Denayrouze.

In effect while the group of divers amongst whom the accidents occurred attained considerable depth of 45 to 54 metres and supported consequently pressures varying from 5.5 atmospheres to 6.4 atmospheres, M Denayrouze with a prudence which does him honour, had given the order not to dive deeper than 35 metres, not to stay longer than two hours and thirty minutes per diver and per day and finally to resurface only very slowly applying one minute per metre of depth. Furthermore the equipment used offers better guarantees than (the standard) dress; the air is supplied proportionally to the needs of respiration, and at a pressure mathematically equal to that of the ambient environment. In these conditions, the blood of the diver must have been far less saturated with free gases, since the pressure was much less and the slowness of the decompression should allow an equilibrium to be established without there being the feared effervescence.

But this moderation to the extreme limit of the depth to be attained singularly reduces the benefits of the enterprise. In fact in the same areas there where one could at 30 metres collect for a value of 100 franc sworth of sponges per day, at 50-60 metres one could collect 1,000 francs worth. Would it be possible, without compromising the life of the

divers, by the means of certain precautions and with the regulating apparatus, to enable work at these extreme depths? Such is the question that we have been asked.

Here, in response, are the propositions which we believed we are able to formulate:

1) It is necessary to take the greatest care in the choice of men who will become engaged as divers. From the moment that it becomes a question of the use of underwater apparatus, the experienced divers of the archipelago present no superiority over men of a good constitution who are not used to diving. In fact what gives superiority to professional divers is that they are able to stay a long time underwater without breathing, while what renders dangerous the time at great depth with under water equipment is to breathe for a long time air at great pressure.

Seamen who volunteer to become divers with the aid of equipment must submit in advance to a detailed medical examination by a doctor. They must be aged at least 20 and 35 at the most. They must be of robust constitution but not overly fat; they will be of average size and acknowledged sober. The integrity of respiratory and circulatory functions must be perfect.

2) During the duration of the fishing campaign divers should receive a wholesome diet (?) On working days one litre of wine per man will be allowed. For men of Muslim religion, one should replace the wine with coffee.

3) Compressed air apparatuses equipped with a regulator would be preferred especially for great depths.

4) The divers should go down as quickly as possible with the aid of a rope ladder with iron rungs without going so rapidly as to feel the effects of pain in the ears.

5) If the depth at which he is going to work is not greater than 30 metres the diver will be able to stay for 2 hours if he feels no discomfort under the water.

6) Attempts could be made to dive deeper but only with divers already experienced in this kind of work, and by reducing the length of their stay underwater proportionally to the increase in depth. These gradual attempts will only be made by increments of 5 metres at the most each time.

7) Decompression shall have to be more prudent as the depth increases. The duration of one minute per metre seems to us to be sufficient.

8) The presence of a doctor at fishing sites near the fishing boats is indispensable in order to provide immediate help in case of an accident.

The same considerations are naturally applicable to divers who earn their living by fishing for coral which is only collected generally from very great depths.